

# Dialogue Concerning the Two Chief World Systems Ptolemaic and Copernican (From the Third Day) *GALILEO 1630*

**Cast of characters:**

**Salviati:** voice of Galileo

**Simplicio:** voice of Peripatetics

**Sagredo:** "impartial" observer

**SALVIATI:** Let us now consider the apparent movement of the sun, attributed by most people to the sun itself, but then, first by Aristarchus, and later by Copernicus, removed from the sun and transferred to Earth. We will take up in order, in accordance with our previous procedure, the arguments by Aristotle and the other ancients. Sagredo, with his quick wit, shall interpose his thoughts as the spirit moves him.

**SAGREDO:** I shall do so with my customary lack of tact; and since you have asked for it, you will be obliged to pardon it.

**SALVIATI:** Now let Simplicio begin to set forth those objections that prevent him from believing that Earth, like the other planets, may revolve about the sun.

**SIMPLICIO:** The first and greatest difficulty is the incompatibility between Earth being at the center, while at the same time being distant from the center. But Earth **is** at the center, as is proved in many ways by Aristotle, Ptolemy, and others.

**SALVIATI:** Very well argued. There can be no doubt that anyone who wants to have Earth move along the circumference of a circle must first prove that it is not at the center of that circle. The next thing is for us to see whether Earth is or is not at that center. Tell me what and where this center is that you mean.

**SIMPLICIO:** I mean by "center," that of the universe; that of the stellar sphere; that of the heavens.

**SALVIATI:** I might very reasonably dispute whether there is in nature such a center, seeing that neither you nor anyone else has so far proved whether the universe is finite and has a shape, or whether it is infinite and unbounded.

**SIMPLICIO:** Aristotle gives a hundred proofs that the universe is finite, bounded, and spherical.

**SALVIATI:** Which are all reduced to one and that one to none at all. For if I deny Aristotle his assumption that the universe is movable all his proofs fall to the ground. But in order not to

multiply our disputes, I shall concede to you for the time being that the universe is finite, spherical, and has a center. Now tell me, Simplicio: if Aristotle had found himself forced by the most palpable experiences to rearrange his order and disposition of the universe, what do you think he would do?

**SIMPLICIO:** I think that if that should happen, the followers of Aristotle. . . .

**SALVIATI:** I am not asking about Aristotle's damn followers; I am asking about Aristotle himself. As for the followers, I know very well what they would do. They, as most reverent and most humble slaves of Aristotle, would deny all the experiences and observations in the world, and would even refuse to look at them, and they would say that the universe must be as Aristotle has written, not as observed in nature. I want to know what Aristotle himself would do.

**SIMPLICIO:** Really, I cannot make up my mind how he would face the difficulty.

**SALVIATI:** Please, do not apply this term "difficulty" to something that may be so. Let us assume out of respect for Aristotle that the universe (of the size of which we have no sensible information beyond the fixed stars) is spherical, and like anything that is spherical in shape and moves circularly, has a center.

**SIMPLICIO:** But how do you deduce that it is not Earth, but the sun, which is at the center of the revolutions of the planets?

**SALVIATI:** This is deduced from most obvious and therefore most powerfully convincing observations. The most palpable of these, which excludes Earth from the center and places the sun there, is that we find all the planets closer to Earth at one time and farther from it at another. The differences are so great that Venus, for example, is six times as distant from us at its farthest as at its closest.

**SIMPLICIO:** But what are the signs that they move around the sun?

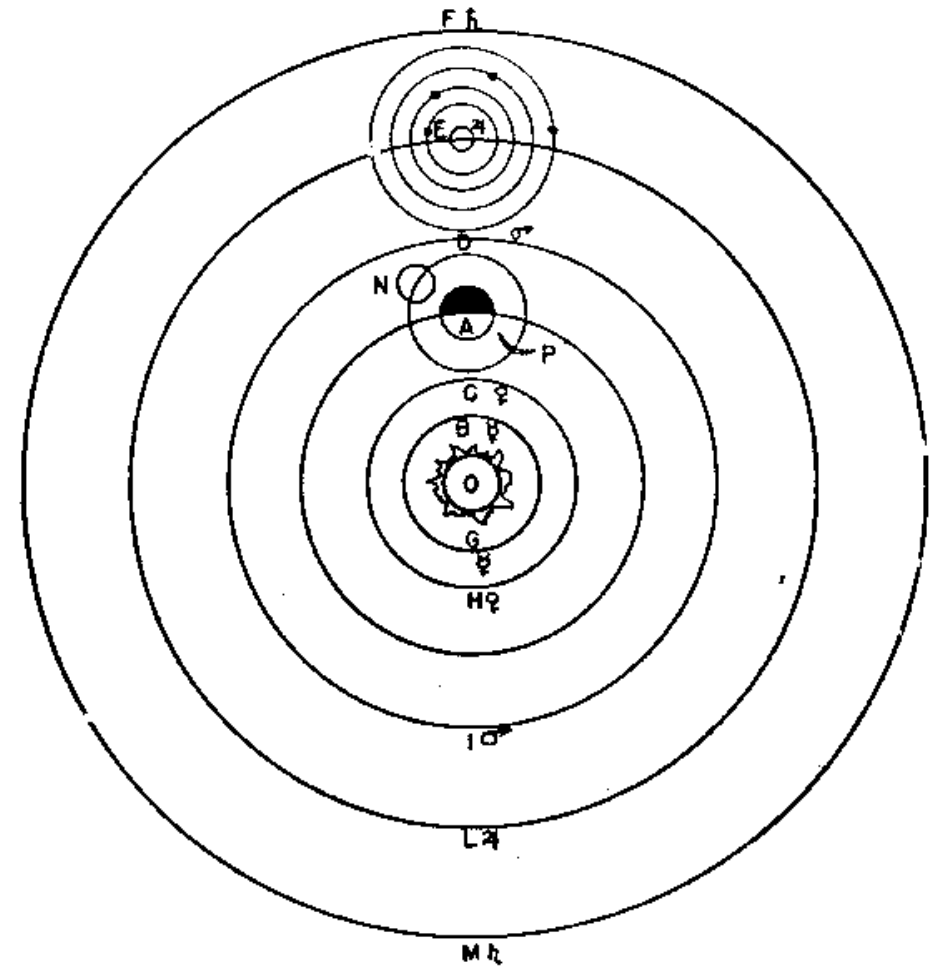
**SALVIATI:** This is reasoned out from finding the three outer planets -- Mars, Jupiter, and Saturn -- are always quite close to Earth when they are in opposition to the sun, and very distant when they are in conjunction with it. This approach and recession is such that Mars when close looks sixty times as large as when it is most distant. Next, it is certain that Venus and Mercury must revolve around the sun, because of their never moving far away from it, and as Venus's changes of shape conclusively prove. As to the moon, it is true that this can never separate from Earth in any way, for reasons that will be set forth more specifically as we proceed.

**SIMPLICIO:** I am not yet convinced of this arrangement at all. Perhaps I should understand it better from the drawing of a diagram.

**SALVIATI:** As you wish. But for your greater satisfaction, and your astonishment, too, I want you to draw it yourself. You will see that however firmly you may believe yourself not to understand it, you do so perfectly, and simply by answering my questions you will describe it exactly. First, since you are sure without my telling you that Earth is located in this universe, mark

some point at your pleasure where you intend this to be located, and designate it by means of some letter.

**SIMPLICIO:** Let this be the place of the terrestrial globe, marked A.



**SALVIATI:** Very well. I know in the second place that you are aware that Earth is not inside the body of the sun, but is distant from it by a certain space. Therefore assign to the sun some other place of your choosing, as far from Earth as you like, and designate that also.

**SIMPLICIO:** Here I have done it; let this be the sun's position, marked O.

**SALVIATI:** These two established, I want you to think about placing Venus in such a way that its position and movement can conform to what sensible experience shows us about it.

**SIMPLICIO:** Let's see, Venus never recedes from the sun beyond a certain interval of forty degrees or so. Moreover, I shall assume that it appears about forty times as large when being retrograde and very small when it is moving forward. Furthermore, when it appears very large, it reveals itself in a horned shape, and when it looks very small it appears perfectly round. These appearances being correct, I do not see how to escape that Venus revolves in a circle around the sun, in such a way that this circle cannot possibly embrace Earth, nor to be between the sun and Earth, nor be beyond the sun. Therefore I shall draw the circle CH around the sun, without having this include Earth.

**SALVIATI:** Venus provided for, it is fitting to consider Mercury, which, as you know, keeping itself even closer to the sun. Therefore consider what place you should assign to it.

**SIMPLICIO:** There is no doubt that, imitating Venus as it does, the most appropriate place for it will be a smaller circle, within this one of Venus and also described about the sun.

**SALVIATI:** Next, where shall we put Mars?

**SIMPLICIO:** Mars, since it does come into opposition with the sun, must embrace Earth with its circle. And I see that it must also embrace the sun; for, it comes into conjunction with the sun and the circle must include the sun as well as Earth because it always appears round. Therefore I can account for the observed phenomena by a giving Mars a motion described by a circle around the sun and embracing Earth, which I mark DI.

**SAGREDO:** How about Jupiter and Saturn?

**SIMPLICIO:** Well Jupiter and Saturn have the same appearances as Mars (although with less variation in Jupiter than Mars and still less in Saturn), so it seems clear to me that we can also accommodate these two planets very neatly with two circles around the sun. The first, for Jupiter, I mark EL; the other for Saturn, called FM.

**SALVIATI:** So far Simplicio you have comported yourself uncommonly well.

**SAGREDO:** Now what about the moon?

**SIMPLICIO:** Following the same method, since we see the moon comes into conjunction and opposition with the sun, it must be admitted that its circle must embrace Earth. But the circle must not embrace the sun, or else when in conjunction it would not look crescent, but round and full of light. Besides, it must get between Earth and the sun in order to cause an eclipse. Thus one must assign to it a circle around Earth, NP, so drawn.

**SALVIATI:** Now what shall we do, Simplicio, with the stars? Do we want to sprinkle them throughout the immense abyss of the Universe at various distances, or place them on a spherical surface extending around a center of their own?

**SIMPLICIO:** I had rather take a middle course, and assign to them an orb described around a definite center and included between two spherical surfaces, a very distant concave one, and

another closer and convex. This might be called the universal sphere, containing within it the spheres of the planets we have already designated.

**SALVIATI:** Well, Simplicio you hosehead, what you have been doing all this while is arranging the universe according to Copernicus, and this has been done **by your own hand!** In all these movements you agree with Copernicus himself. It now remains to apportion three things among the sun, Earth, and the stellar sphere: the state of rest, which appears to belong to Earth; the annual motion through the zodiac, which appears to belong to the sun; and the daily movement of the stars, which appears to belong to the stellar sphere. And since it is true that all the planetary orbs (I mean Mercury, Venus, Mars, Jupiter, and Saturn) move around the sun as a center, it seems most reasonable for the state of rest to belong to the sun rather than to Earth. As to Earth, which is placed in the midst of moving objects, I mean between Venus and Mars, one of which makes its revolution in nine months and the other in two years, a motion requiring one year may be attributed to Earth much more elegantly than a state of rest, leaving the state of rest for the sun. And such being the case, it necessarily follows that the apparent rotation of the stars also belongs to Earth. See, then, how neatly the motion of the stars is taken away from the universe, and how the fixed stars (which are so many suns) agree with our sun in enjoying perpetual rest. See also what great simplicity is to be found in this rough sketch, yielding the reasons for so many phenomena in the heavenly bodies.

**SAGREDO:** Even though Simplicio stands there with his mouth open, I see this very well indeed. But just as you deduce from this simplicity a large probability of truth, others may make the opposite deduction from it. If this arrangement makes so much sense, why it has found so few followers in the course of centuries; why it has been refuted by Aristotle himself, and why even Copernicus is not having any better luck these days.

**SALVIATI:** Sagredo, if you had suffered even a few times, as I have so often, from hearing the sort of follies that are designed to make the common people unwilling to listen to this idea (let alone assent to it), then I think your astonishment at finding so few men holding this opinion would dwindle a good deal. It seems to me that we can have little regard for **imbeciles** who take it as a conclusive proof of Earth's motionlessness that Earth is too heavy to climb up over the sun and then fall headlong back down again. There is no need to bother about such men as these, whose number is legion, or to take notice of their fooleries. Besides, with all the proofs in the world what would you expect to accomplish in the minds of people who are too stupid to recognize their own limitations? No, Sagredo, my surprise is very different from yours. You wonder that there are so few followers of the Copernican opinion, whereas I am astonished that there have been **any** at all who have embraced and followed it. Nor can I ever sufficiently admire those who have taken hold of this opinion and accepted it as true. They have through sheer force of intellect done such violence to their own senses as to prefer what reason told them over that which sensible experience plainly showed them to the contrary. For the arguments against the whirling of Earth are very plausible, and the fact that the Ptolemaics and Aristotelians and all their disciples took them to be conclusive is indeed a strong argument of their effectiveness. The experiences which overtly contradict the annual movement of Earth are indeed so great in their apparent force that, I repeat, **there is no limit to my astonishment when I reflect that Copernicus was able to make reason so conquer sense that, in defiance of the latter, the former became mistress of his belief.**